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PRELIMINARY DESIGN AND COST STUDY OF RECIRCULATING CHROMATE RINSE SYSTEM FOR AIRCRAFT CORROSION CONTROL

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Naval Air Development Center

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WARMINSTER, PA. 18974

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PRELIMINARY DESIGN AND COST STUDY OF RECIRCULATING CHROMATE RINSE SYSTEM FOR AIRCRAFT CORROSION CONTROL

DESIGN PHASE ONE

AIRTASK NO. A3405343/200B/2F00554401
WORK UNIT 02
GSED P.O. 2-8013 of 22 SEP 71

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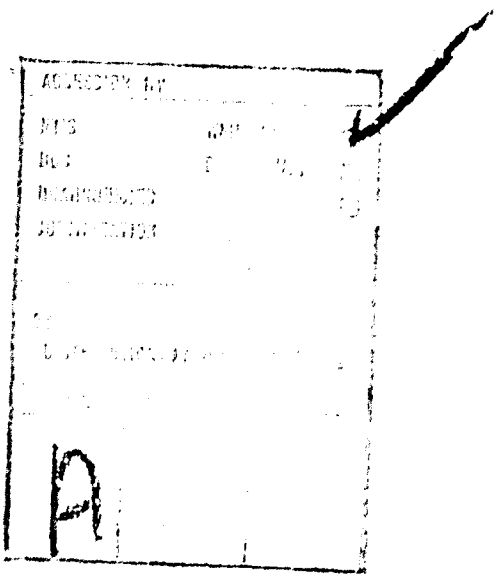

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14 KEY WORDS	LINK A		LINK B		LINK C	
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Water Rinse						
Aircraft						
Corrosion Control						
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Recirculating Rinse						

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WARMINSTER, PA. 18974

Air Vehicle Technology Department

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A preliminary design and cost study was made for a recirculating chromate rinse system.

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III

EVALUATION AND DISCUSSION

INTRODUCTION

Aircraft rinse facilities are presently employed to create a short rain storm effect that removes corrosive salt deposits from aircraft operating in salt laden environments. While water rinsing has been effective in reducing corrosion, the rate of attack can be further reduced by introducing a small amount of corrosion inhibitor, such as potassium dichromate, into the rinse water. Traces of the inhibitor which form a molecular film on exposed corrodible surfaces should reduce not only surface attack but also galvanic corrosion in critical areas. A preliminary design and cost study for a recirculating chromate rinse was undertaken under AIRTASK A3405343/200B/2F00524401, Work Unit No. 2 and GSED P.O. 2-8013 (22 Sep 1971).

The initial concept for introducing a corrosion inhibitor into an aircraft rinse was to add the inhibitor directly to the rinse water system. But since chromates are toxic to aquatic life, the rinse effluent would need chromate removal treatment before being discharged to the storm sewers. Investigation of treatment plants with large capacity chromate separators showed that chemical precipitation would be the most feasible approach for removal but that operating and maintenance costs would be high. At that point it was felt that these high costs could be avoided by separating the chromate rinse from the fresh water rinse. The aircraft would be first rinsed with fresh water then at a seperate site, sprayed with a chromate rinse. Following the spraying of chromate solution, the rinse would be collected and reused to reduce the cost of a large treatment plant.

A preliminary design and cost study was undertaken for a recirculating chromate rinse system.

DISCUSSION

The design of an aircraft rinse apparatus incorporating a chromate rinse system is complicated by three factors: 1) the effectiveness of potassium dichromate as a corrosion inhibitor is diminished as the salinity of the chromate rinse water increases, 2) chromates and salts dissolved in the rinse water can be separated but only slowly and expensively with reverse osmosis or ion exchange techniques, and 3) chromates are toxic to aquatic life and, therefore, cannot be discharged to the sewer system.

An aircraft rinse apparatus expanded to include chromate treatment must make use of two separate spray systems, where the first system is a fresh water rinse and the second system recirculates the chromate rinse solution. This design requires that the first fresh water rinse remove salt deposits to avoid contamination of the

chromate rinse and that a suitable length of taxiway exist between the two systems to avoid contamination of the fresh water rinse effluent with chromates.

Design considerations include:

1. A high impact spray system to deliver a large volume of water in the short rinsing cycle.

2. A recirculating chromate rinse system where suspended solids and oils are removed from the system prior to respraying.

3. A small treatment facility capable of removing chromates from the rinse prior to ultimate disposal via the sewers.

4. A highly automated system, with little maintenance or manual operation required.

5. A rinse system capable of handling a wide range of aircraft from small helicopters to large fixed wing aircraft.

Process equipment required for such a water rinse - chromate rinse apparatus would include the following (see Figures 1, 2 and 3):

1. A centrifugal pump to power each spray system, rated at 300 psi and 1000 gpm for the fresh water rinse and 300 psi and 500 gpm for the recirculating chromate rinse.

2. One centrifugal pump rated at 100 gallons per minute at 75 pounds per square inch for pumping chromate rinse water from the settling tank through a filter and into the storage tank.

3. Two vertical cylindrical 20,000 gallon tanks functioning as a settling tank to remove solid particles and a storage tank for the filtered chromate rinse.

4. One vertical cylindrical 5,000 gallon holding tank to collect rain water run-off for make-up water or disposal via the water purification unit.

5. Water purification unit capable of handling 400 gallons per hour to purify rain water contaminated with chromates prior to disposal via the sewer system.

6. One filter capable of handling 100 gallons per minute to remove suspended solids.

7. One deflector screen to knockdown chromate spray from the prop wash.

8. 210 spray nozzles delivering 10 gallons per minute at 300 pounds per square inch to produce a dense, high impact spray.

RESULTS OF DESIGN STUDY

The entire rinse apparatus as represented in Figures 1, 2 and 3 is comprised of two systems: 1) a fresh water rinse to remove salt deposits and 2) a recirculating rinse with dilute chromate inhibitor to deter future corrosion. While the salt laden water from the fresh water rinse is sent directly to the storm sewer as in previous designs, the chromate solution is retained, held to remove solids, filtered, and reused via a spray system similar to that of the fresh water system.

The cost of equipment, auxiliary materials, and labor for the entire apparatus, including the necessary taxiway and two pump houses totals $322000. This figure does not account for any indirect costs (freight, insurance, construction overhead), contingency funds, or contractors fee.

The follcwing table shows a breakdown of costs:

CHROMATE RINSE SYSTEM	MATERAL	LABOR	TOTAL
Taxiway and drainage	48 520	36 040	84 560
Process equipment	70 080	23 975	94 055
Pump nouses	4 150	2 750	6 900
	122 750	62 765	185 515

FRESH WATER RINSE SYSTEM	MATERIAL	LABOR	TOTAL
Taxiway and drainage	48 520	36 040	84 560
Process equipment	32 670	14 725	47 395
Pump houses	2 650	1 750	4 400
	83 840	52 515	136 355
TOTAL COST BOTH SYSTEMS	206 590	115 280	321 870

It is important to note that where a fresh water rinse facility and sufficient taxiway exists, a recirculating chromate rinse system can be installed for $101,000, which includes proce . equipment and pump house.

CONCLUSIONS

Due in particular to the taxiway construction costs which amount to 53% of labor and material cost for the entire apparatus, this project appears more expensive than had been initially anticipated. This design, however, is superior to the initial single rinse concept due to anticipated decreased maintenance, decreased operating costs, and a more automated system design.

RECOMMENDATIONS

It is recommended that a prototype water rinse -- chromate rinse apparatus be constructed as outlined in this preliminary report and that a monitoring project be undertaken to optimize a final deisgn.

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED

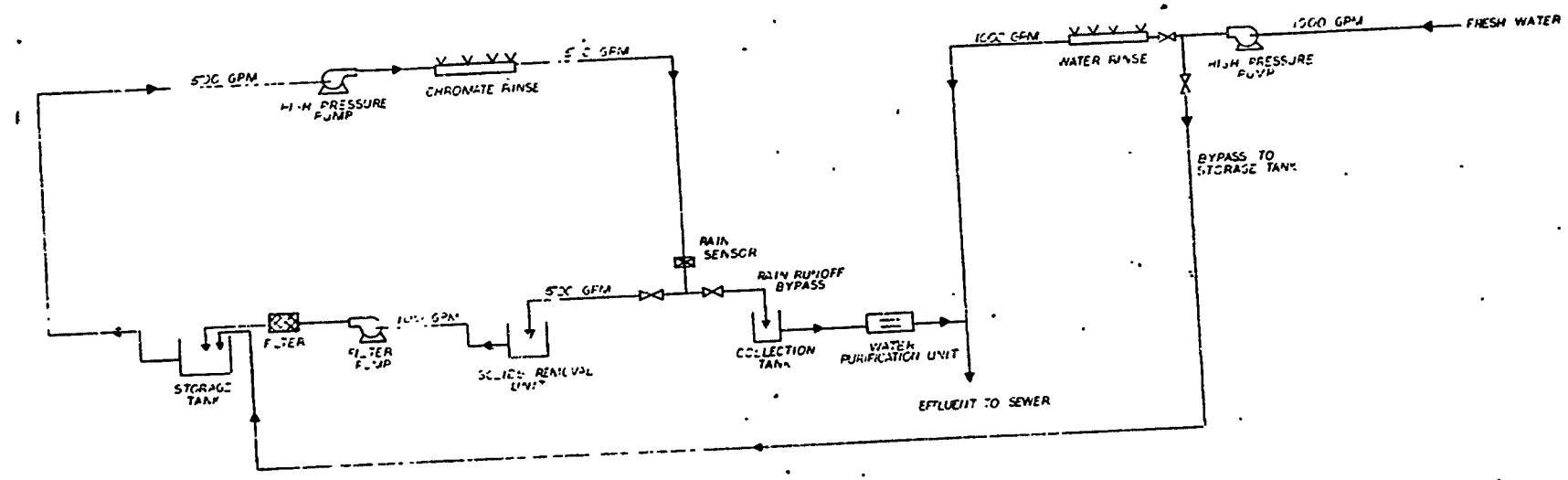
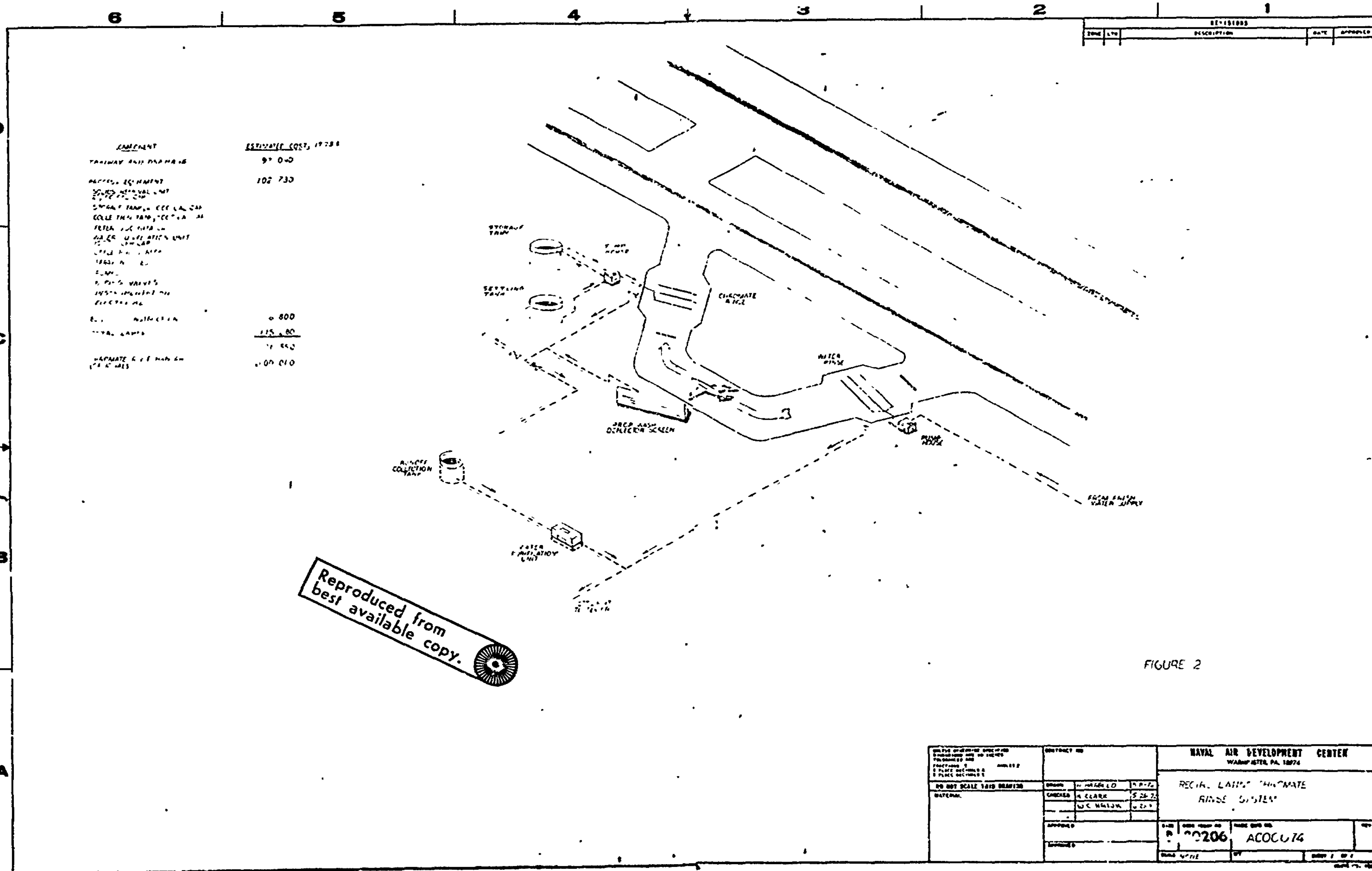


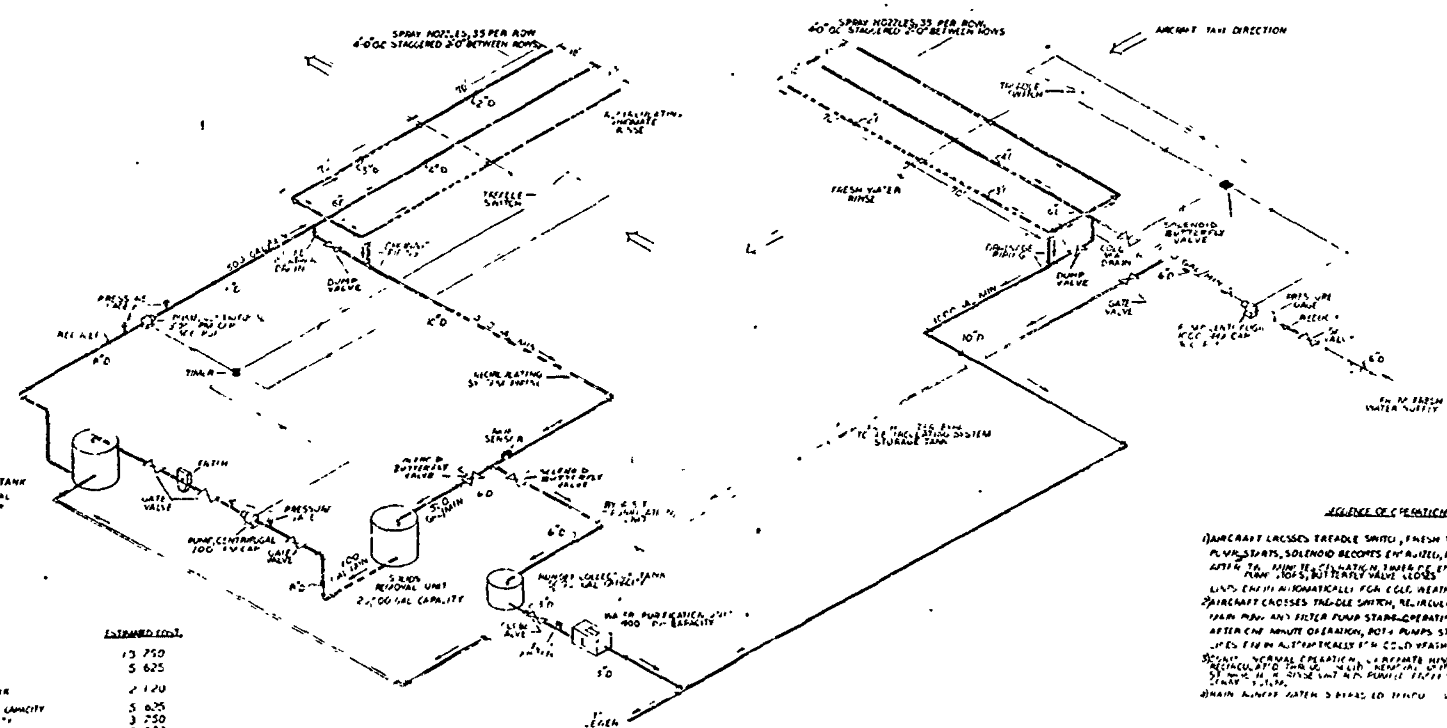
FIGURE 1

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS ± 2 PLACE DECIMALS ± 3 PLACE DECIMALS ± ANGLES ±	CONTRACT NO	NAVAL AIR DEVELOPMENT CENTER WARMINSTER, PA. 18974	
DO NOT SCALE THIS DRAWING	DRAWN [illegible]	RE-CIRCULATING CHROMATE RINSE SYSTEM	
MATERIAL	CHECKED A. CLARK		
	[illegible]		
	APPROVED	SIZE C	CODE IDENT NO 80206
	APPROVED	SCALE NONE	WT
		NADC DWG NO. AC00076	REV
		SHEET 1 OF 1	

PLATE NO 1520

NAVMATDEFCOM-4420/7 (REV. 9-67)


ESTIMATED COST, 1973 $
97 040
102 730
6 800
STORAGE TANK
SETTLING TANK
CHROMATE RINSE
WATER RINSE
OVERSPRAY DEFLECTOR SCREEN
RUNOFF COLLECTION TANK
FROM FRESH WATER SUPPLY
NAVAL AIR DEVELOPMENT CENTER
WARMINSTER, PA. 18974
ACOC074
FIGURE 2



PROCESS EQUIPMENT	ESTIMATED COST
[illegible] PURIFICATION UNIT	13 750
SOLIDS REMOVAL UNIT [illegible]	5 625
[illegible] COLLECTION TANK [illegible]	2 120
STORAGE TANK [illegible] GAL CAPACITY	5 625
[illegible]	3 750
[illegible]	880
PUMPS	
[illegible]	12 100
[illegible]	6 870
[illegible]	1 500
[illegible] STEEL	15 285
[illegible]	10 020
[illegible]	5 205
DEFLECTOR SCREEN	5 000
	102 730

SEQUENCE OF OPERATION

1) AIRCRAFT CROSSES TREADLE SWITCH, FRESH WATER RINSE SYSTEM PUMP STARTS, SOLENOID BECOMES ENERGIZED, BUTTERFLY VALVE OPENS [illegible] PUMP STOPS, BUTTERFLY VALVE CLOSES [illegible] AUTOMATICALLY FOR COLD WEATHER OPERATION

2) AIRCRAFT CROSSES TREADLE SWITCH, RECIRCULATING SYSTEM [illegible] AND FILTER PUMP START OPERATING AFTER ONE MINUTE OPERATION, BOTH PUMPS STOP [illegible] AUTOMATICALLY FOR COLD WEATHER OPERATION

3) [illegible] NORMAL OPERATION, [illegible] RINSE WATER IS RECIRCULATED [illegible]

4) [illegible]

LEGEND

[illegible] RINSE WATER

— ELECTRICAL CIRCUIT

FIGURE 3

NAVAL AIR DEVELOPMENT CENTER

D 80206

A P P E N D I X A

Cost Study fo · Complete Water Rinse Chromate Rinse Apparatus

COST STUDY

I. Site Development. Taxiway and drainage system (cost information obtained from reference (b))

A. Chromate Rinse System.

No. of Units	Item	Material	Labor	Total
4600 yd^3	Excavation, fill	5320	1150	6470
1200 yd^2	Limerock base	930	90	1020
7100 yd^2	Stabilizer base	3330	3330	6660
7100 yd^2	Flex concrete	38100	30630	68730
1200 yd^2	Asphaltic concrete	840	840	1680
		$48520	$36040	$84560

B. Water Rinse System.

Same as above Chromate Rinse System

II. Process and Auxilliary Equipment (Cost information obtained from reference (a)).

A. Chromate Rinse System.

1. Process equipment.

No. of units	Item	Material Cost
1	Pump, centrifugal, 500 gpm, 305 psi	6,870
1	Pump, centrifugal, 100 gpm, 75 psi	1,500
2	Tank, cylindrical, vertical, 20,000 gallon, carbon steel	11,250
1	Tank, cylindrical, vertical 5000 gallon, carbon steel	2,120
1	Water purification unit, 400 gph	18,750
1	Filter assembly	3,750
1	Deflector screen	5,000
105	Spray nozzles, 10 gpm @ 300 psi	3,940
		$53,200

Assume Labor cost = 30% of material cost

Materials	53,200
Labor	15,960
Total	$69,160

2. Instrumentation

No. of Units	Item	Material	Labor	Total
4	Pressure gauges	250	100	350
1	Flow meter	370	200	570
1	Timer, treadle switch	220	100	320
1	Rain Sensor	630	130	760
		$1470	$530	$2000

3. Piping

No. of Units	Item	$/ft Installed	Total
250 ft	10" cast iron	18.10	4525
300	8" cast iron	15.00	4500
50	6" steel	6.70	335
140	4" steel	4.00	560
240	3" steel	2.70	650
140	2" steel	1.40	200
			$10770

Assuming 44% of Total Cost is Labor
Material Cost = $6030
Labor Cost = $4740

4. Valves

No. of Units	Item	Material	Labor	Total
3	8" Gate, cast iron	1970	90	2060
1	3" Globe, steel	220	10	230
3	6" Butterfly, Solenoid operated	2100	140	2240
		$4290	$240	$4530

5. Fittings

No. of Units	Item	Material	Labor	Total
2	3" Reducers, steel	10	50	60
1	8" Reducer, cast iron	35	50	85
5	10"-90° Elbows, cast iron	840	410	1250
10	8"-90° Elbows, cast iron	560	340	900
2	6"-90° Elbows, steel	45	85	130
2	10"-Tees, cast iron	330	165	495
1	6"-Cross, steel	75	50	125
		$1859	$1150	$3045

6. Electrical

No. of Units	Item	Material	Labor	Total
17	Light fixtures	1355	1355	2710
400 ft	Conduit	600		600
1000 ft	Cable, wire	1240		1240
		$3195	$1355	$4550

7. Subtotals

Category	Material	Labor	Total
Process equipment	53200	15960	69160
Instrumentation	1470	530	2000
Piping	6030	4740	10770
Valves	4290	240	4530
Fittings	1895	1150	3045
Electrical	3195	1355	4550
	$70080	$23975	$94055

B. Water Rinse System

1. Process equipment

No. of Units	Item	Material Cost
1	Pump, centrigual, 1000 gpm, 305 psi	12100
105	Spray nozzles, 10 gpm @ 300 psi	3940
		$16040

Assume Labor cost = 30% of material cost
Materials = 16040
Labor = 4810
$20850

2. Instrumentation

No. of Units	Item	Material	Labor	Total
1	Timer, treadle switch	220	100	320
2	Pressure gauges	125	50	175
		$345	$150	$495

3. Piping

No. of Units	Item	$/ft Installed	Total
500 ft	10" cast iron	18.10	9050
400	8" cast iron	15.00	6000
50	6" steel	6.70	335
140	4" steel	4.00	560
140	3" steel	2.70	380
140	2" steel	1.40	200
			$16525

Assuming 44% of Total Cost is Labor
Material Cost = $9255
Labor Cost = $7270

4. Valves

No. of Units	Item	Material	Labor	Total
1	8" Gate, cast iron	660	30	690
2	6" Gate, steel	930	50	980
1	6" Butterfly, Solenoid operated	700	95	795
		$2290	$175	$2465

5. Fittings

No. of Units	Item	Material	Labor	Total
2	3" Reducers, steel	10	50	60
1	8" Reducers, cast iron	35	50	85
5	10"-90° Elbows, cast iron	840	410	1250
2	6"-90° Elbows, steel	45	85	130
3	10"-Tees, cast iron	490	250	740
1	6"-Tees, steel	50	70	120
1	6"-Cross, steel	75	50	125
		$1545	$965	$2510

6. Electrical

No. of Units	Item	Material	Labor	Total
17	Light fixtures	1355	1355	2710
400 ft	Conduit	600		600
1000 ft	Cable, wire	1240		1240
		$3195	$1355	$4550

7. Subtotals

Category	Materials	Labor	Total
Process equipment	16040	4810	20850
Instrumentation	345	150	495
Piping	9255	7270	16525
Valves	2290	175	2465
Fittings	1545	965	2510
Electrical	3195	1355	4550
	$32675	$14725	$47395

III. Process Buildings - Pump houses (Cost information obtained from reference (a))

A. Chromate Rinse System

	Material	Labor	Total
Pump house 12 ft by 20 ft	4150	2750	6900

B. Water Rinse System

Pump house 12 ft by 12 ft	2650	1750	4400
	$6800	$4500	$11300

IV. Total Cost of Water Rinse and Chromate Rinse Systems

A. Chromate Rinse System

	Materials	Labor	Total
Site Development	48520	36040	84560
Process equipment	70080	23975	94055
Process buildings	4150	2750	6900
	$122750	$62765	$185515

B. Water Rinse System

Site Development	48520	36040	84560
Process equipment	32670	14725	47395
Process buildings	2650	1750	4400
	$83840	$52515	$136355

C. Total Cost

	$206590	$115280	$321870

REFERENCES

(a) Popper, Herbert, ed., Modern Cost Engineering Techniques, McGraw-Hill, Inc., New York 1970.

(b) Publi Works Contract N62467-69-C-0106, U.S. Naval Air Station, Jacksonville, Florida (Contract for wash and rinse racks).